

TWO-DIMENSIONAL FLOOD-INUNDATION MODEL OF THE FLINT RIVER AT ALBANY, GEORGIA

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Abstract. The City of Albany, Dougherty County, and the U.S. Geological Survey (USGS) are using recent digital elevation model data and a USGS-developed two-dimensional hydrodynamic flow model to determine potential flow characteristics of future flooding along a 4.6-mile reach of the Flint River in Albany. The flow model is being used to develop incremental, 1-foot vertical separation, flood surfaces that will correspond to streamflow values from gage heights at the USGS Albany streamgage from about 180 feet (the 10-year recurrence interval flood) through about 193 feet (the peak elevation for Tropical Storm Alberto during 1994).

INTRODUCTION

The City of Albany, Dougherty County, and the USGS are cooperating on floodplain studies along the Flint River in Albany, Georgia (see Fig. 1). Since 1994, the City of Albany has experienced two large floods. Tropical Storm Alberto (TSA), during July 1994, caused record-breaking flooding in much of the Flint River Basin. The maximum flood flow in Albany was about 120,000 cubic feet per second (ft^3/s) at about 193 feet (ft) elevation above mean sea level (msl) at the USGS Albany streamgage. The probable recurrence interval (RI) of the flood was estimated to be about a 200–300-year event. The flood inundated much of Albany, caused widespread community infrastructure and property damage, affected public safety and health, and required the evacuation of approximately 75,000 people. A regional, winter storm, during March of 1998, also caused significant flooding in Albany and required the evacuation of approximately 14,000 people. The flood was estimated to be about a 70-year RI, at about $86,000 \text{ ft}^3/\text{s}$ flow, with a flood elevation of about 187 ft msl.

MODELING METHOD

A two-dimensional, steady-state flow model developed by the USGS Hydrologic Instrumentation Facility, based on finite-element (FE) principles (FESWMS), is being used to develop two-dimensional flood surfaces for the

Albany floodplain. Flood surfaces, in 1-foot increments, will be developed that correspond to streamflow values from gage heights at the USGS Albany streamgage from about 180 ft (the 10-year recurrence interval flood) through about 193 ft (the peak elevation for Tropical Storm Alberto during 1994). These surfaces will be printed over 1-foot resolution gray-scale digital orthophotos. The USGS streamgage in Albany is a National Weather Service flood-forecast location, and flood-forecast predictions are indexed to gage heights at the streamgage. These maps will be used by Albany–Dougherty County for planning for potential future flood events. High-resolution images of these maps, as well as geographic-information-system compatible data sets are being written to CD-ROM. In addition to the flood-extent information provided by this effort, depth, velocities, sectional-flow and flow-direction vectors will be calculated. These vectors can be displayed and used to develop warnings and hazard scales for a flood disaster.

MODELING PROCEDURE

The effort included field and background investigations, data acquisition, and model development. Numerous field visits were required to gain sufficient site information, flood and flood-damage history, bridge structure characteristics, stream cross-sections, and land-cover characteristics. Background investigations included obtaining and reviewing previous reports and model runs such as: Section 205 Detailed Project Report, Flint River Albany, Georgia, U.S. Army Corps of Engineers, Mobile District, 2002; Flood Insurance Study for Dougherty County Georgia and Incorporated Areas, Federal Emergency Management Agency, 2001; and Section 205 Detailed Project Report and Environmental Assessment Kinchafoonee Creek and Hopen Ditch, Albany Georgia, U.S. Army Corps of Engineers, 1997.

During August 2003, the initial elements of the model compilation began, and a suitable model grid was established. The reach being modeled is shown in Figure 1. Model cross-sections were determined for the study reach and georeferenced. Additional digital elevation model (DEM) detail was added at river and cross-section anomalies.

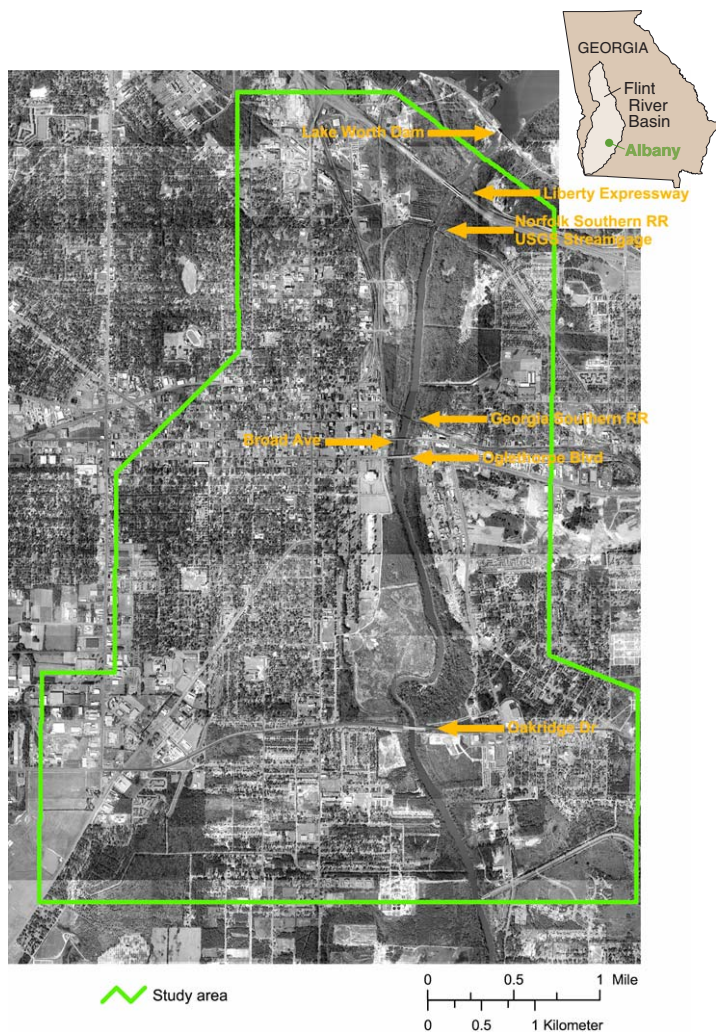


Figure 1. The flood inundation study area in Albany, Georgia, showing all major crossings. [USGS, U.S. Geological Survey; RR, Railroad]

All areas in the study reach were classified into five land-cover categories: channel, clear, forest, high-density urban, and low-density urban. Roughness coefficients were assigned to each land-cover category. The boundary conditions used for the model are inflow volume and outflow elevation. The initial boundary conditions used to start the model were an inflow of 0 ft³/s and an outflow elevation of 231 ft msl. Next the inflow was gradually increased to 120,000 ft³/s. Once the maximum inflow was achieved, the outflow boundary condition was slowly reduced to 185 ft msl. At this point, bridge piers and deck elevations for the four highway and two railroad bridges were placed into the model.

In the Albany area, during TSA, a number of areas near the Flint River were inundated due to underground hydraulic connections. To show these low-lying areas, the river surface elevations were extended beyond the river banks using Geographic Information Systems analysis. A number of these low areas with elevations below the river surface elevation are also mapped in Figure 2. Many of these areas were inundated during TSA.

CALIBRATION

Initial model calibration runs involved running the model for the peak streamflow observed during 1994 during TSA, about 120,000 ft³/s, which was estimated to be about 200–300-year RI. An adjustment of the eddy viscosity value for the model was done until the water-surface elevation at the USGS Albany streamgage was 193 ft msl. This model calibration essentially reproduced the measured TSA floodplain. Figure 2 shows the floodplain generated by the model compared with the recorded floodplain in Albany on July 11, 1994. The actual flood elevations and modeled values are in close agreement. The model was also calibrated against the March 1998 flood of approximately 86,000 ft³/s at 187 ft msl.

CURRENT FLOODPLAIN ANALYSIS

Currently (2005), the model is being utilized to produce incremental 1-foot floodplains as specified in the original project plans discussed above. The model is also being used to develop a new Digital Flood Insurance Rate Map for Albany. In addition, the model is being used to analyze flow characteristics such as velocity, depth, and streamflow in sections of the floodplain and river. Current model runs incorporate the effects, to date, of the partially completed Riverwalk. The Riverwalk is a new park adjacent to the Flint River comprised of greenspace and pedestrian walkways.

POTENTIAL EFFECTS OF UPSTREAM DEVELOPMENT ON FLOOD FLOWS

In addition to the streamflow modeling within the Albany area, this study begins a reconnaissance-level assessment of upstream development on flood flows in Albany. This assessment is made by reviewing data from USGS Flint River Basin streamgaging stations (Fig. 3), having sufficient records, and examining land-use change in rapidly-developing areas of the Flint River Basin. Changes in the Flint River Basin that might send higher peak flows into the City of Albany are profoundly important.

FLOOD MITIGATION PLANNING

Albany is growing rapidly and has a number of active community improvement projects. Some of the projects, such as the planned 8.5-mile extension to the new Riverwalk along the west bank of the Flint River, will improve floodwater conveyance in the study reach. The community has invited a number of Federal, State and local agencies to continue to partner with the community by helping to evaluate a variety of flood mitigation measures.

Explanation

- Potentially flooded low areas
- 2-dimensional flood-model inundation
- Study area
- TSA inundation estimate
- FIRM 100-year floodplain
- FIRM 500-year floodplain

0 0.25 0.5 1 Mile
0 0.25 0.5 1 Kilometer

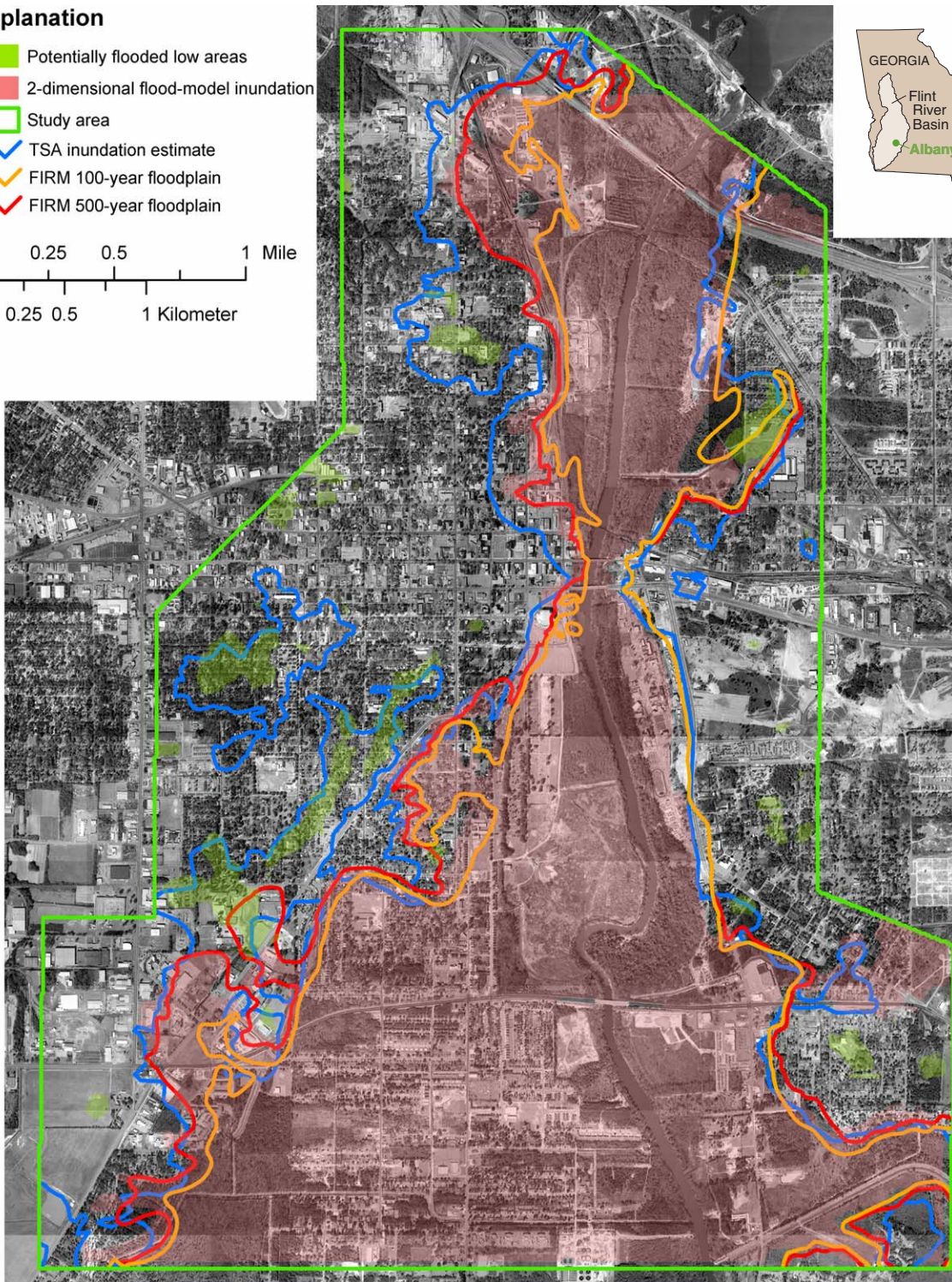


Figure 2. Flood inundation model compared with Tropical Storm Alberto (TSA) and Federal Emergency Management Agency's digital Flood Insurance Rate Maps (FIRM).

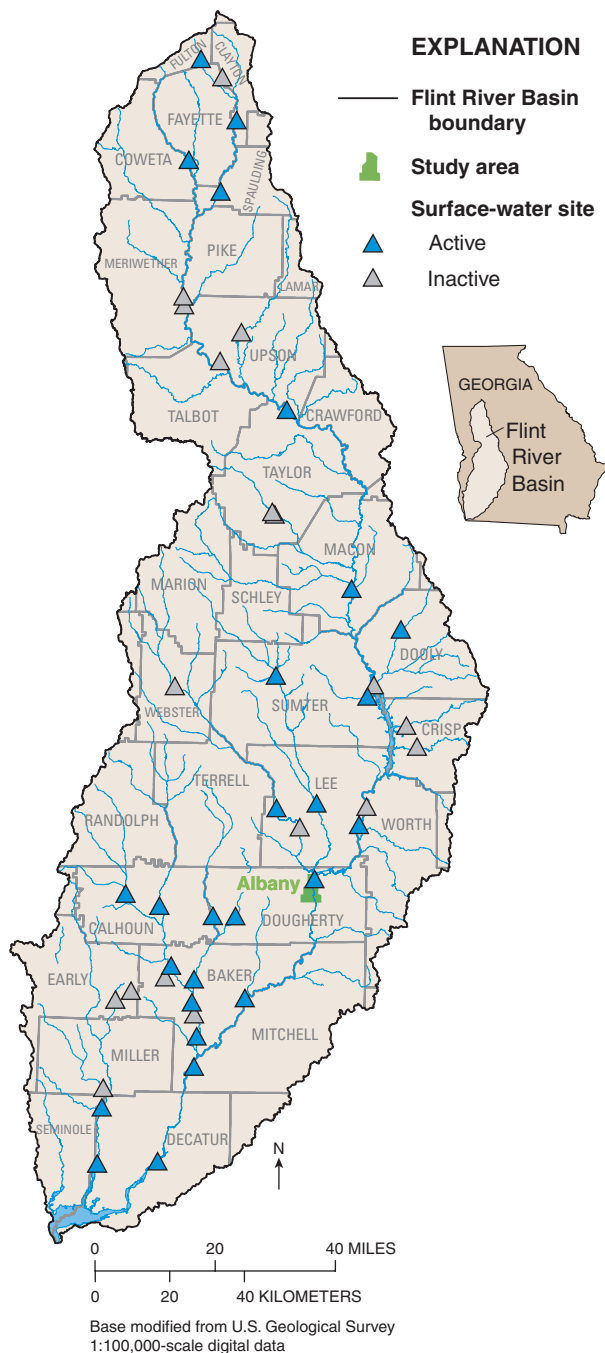


Figure 3. Active and inactive U.S Geological Survey surface-water sites in the Flint River Basin.

For example, the U.S. Army Corps of Engineers is conducting a feasibility study of construction of one or more dikes in the study reach to contain the design flood. The subject two-dimensional hydrodynamic flow model can be used to help assess impacts of future near-river development on flooding in Albany. This includes using the model to help decide on, prioritize, or assess the effects of any stream bank, stream channel, or roadway/bridge configuration modifications to reduce flooding. All significant flood-flow improvements will be reflected in the Albany streamgage stage-discharge relation.

Perhaps the principle value of the hydrodynamic model will be its usage to aid the planning and engineering processes by helping solve specific problems prior to any large flood event. For example, high-resolution hydrodynamic and DEM models can markedly improve flood-disaster management and emergency transportation operations and planning.

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